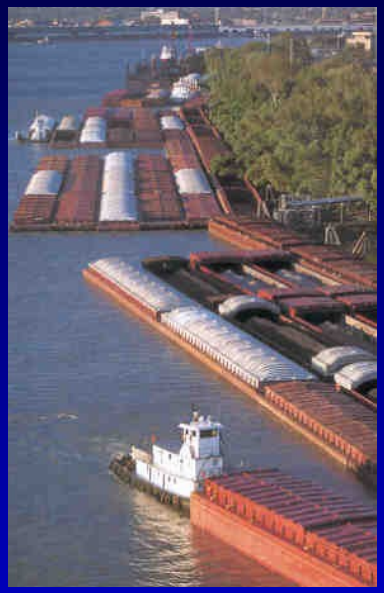
Navigation Systems / Continuing GI R&D Program

Lock and Dam Inspection and Emergency Repairs Workshop
April 18-20, 2006
Vicksburg, MS



Business Area Leader: Angie Premo*
Program Manager: James Clausner

Navigation Systems

Presentation Today

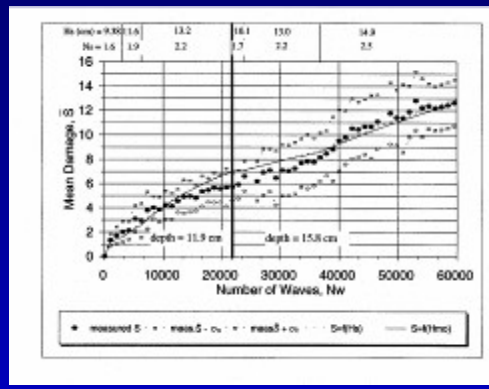
- Recent Progress/Completed Efforts
- Describe Research Program
  - Program Structure
  - Research Needs/Direction
  - Focus Areas and Work Units

Navigation Systems (02-05) Significant Accomplishments

Structures

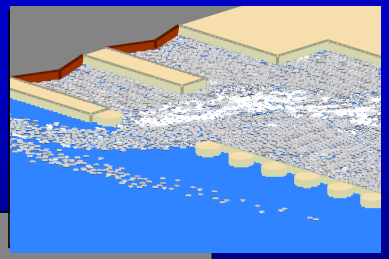
Objective: To improve design guidan
lower first costs and minimize O&M

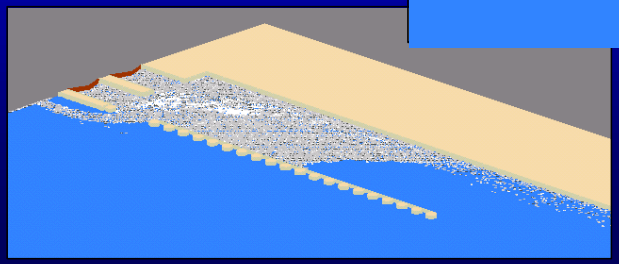
Breakwaters



ICE PASSAGE THROUGH A GUARDWALL

Simulating ice passage through a gap in a guard wall using calculated water velocities from HYVEL2D





Bendway Weirs

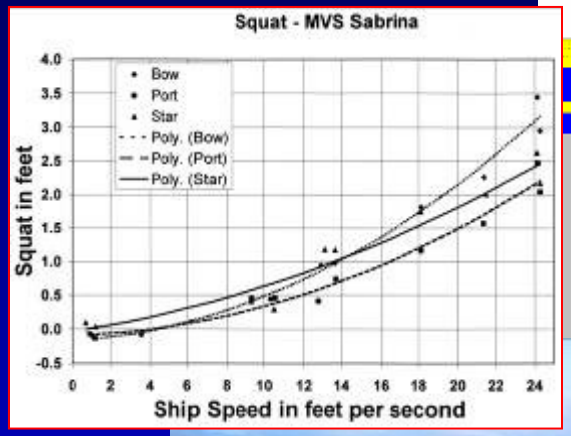
Riverine Training Structures

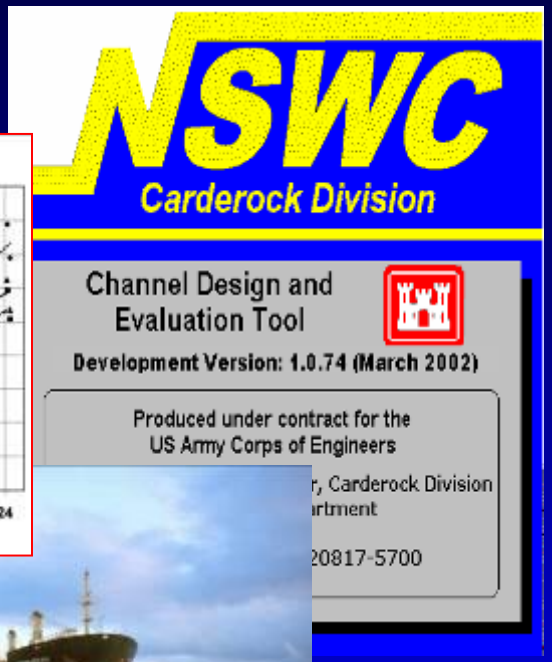
Research and

Navigation Systems
Significant Accomplishments

Channels and Harbors - Navigability and Vessel Motion

Objective: Develop methods for predicting and assessing vessel motion and provide guidance for safe operations and efficient designs




NSWC
Carderock Division
Channel Design and Evaluation Tool
Development Version: 1.0.74 (March 2002)
Produced under contract for the US Army Corps of Engineers

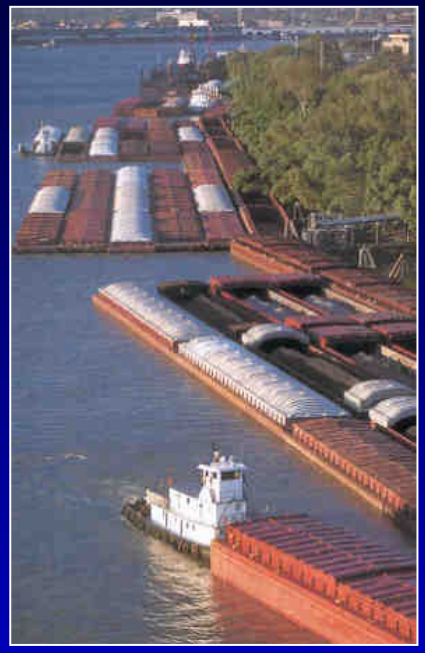
Underkeel Clearance and Channel Design

Lock Approach Guidance

Navigation Systems Program Structure

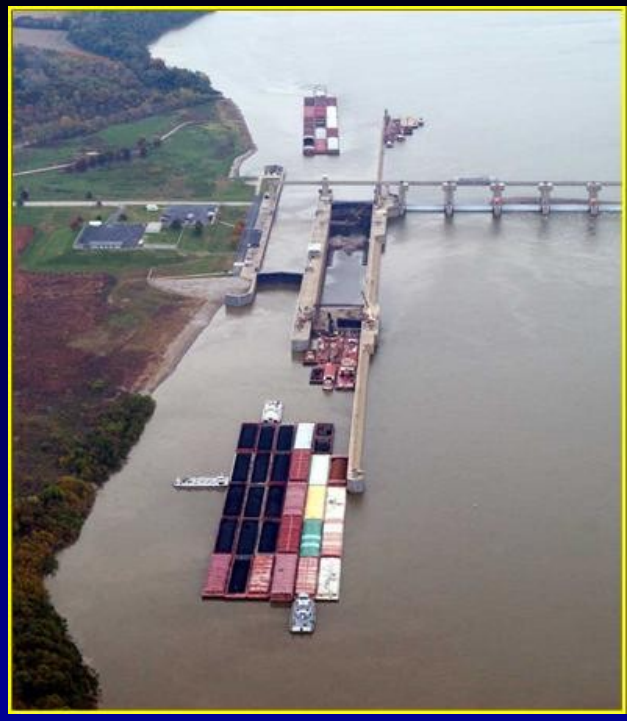
- Program Management and Technical Transfer
- Deep Draft Navigation
  - Channels and Harbors
  - Structures
- Inland Navigation
  - Hydrodynamics
  - Infrastructure
- Hydropower
- Asset Management

Inland Navigation Focus Area



Program Manager: James Clausner
Focus Area Team: Mike Sharp, John Hite

Inland Hydrodynamics Work Area



- **Problems**
  - Inland Traffic Increasing/Capacity at limit
  - Increasing capacity w/ safe reliable, environmentally sustainable channels
  - Improved design tools
  - Vessel impacts, scour, emergency repairs, fish passage, ice/debris, fill empty systems, float in construction
- **Products**
  - Vessel Impact Models
  - Improved/Innovative Lock Entrance Structures
  - Emergency Repair Structures/float in construction
- **Benefits**
  - Reduce Costs, increase safety
  - Reduced environmental impacts
  - Increased reliability, increase capacity

Inland Hydrodynamics Work Area
Work Units

- Existing Work Units
  - Hydrodynamic Design for Inland Structures
    - Environmental Effects
    - Hydraulic Structure Design
    - Hydraulic Structure Performance
  - Barge Impact Load Models and Criteria
  - Scour Protection Assessment

Hydrodynamic Design for Inland Structures: Environmental Effects

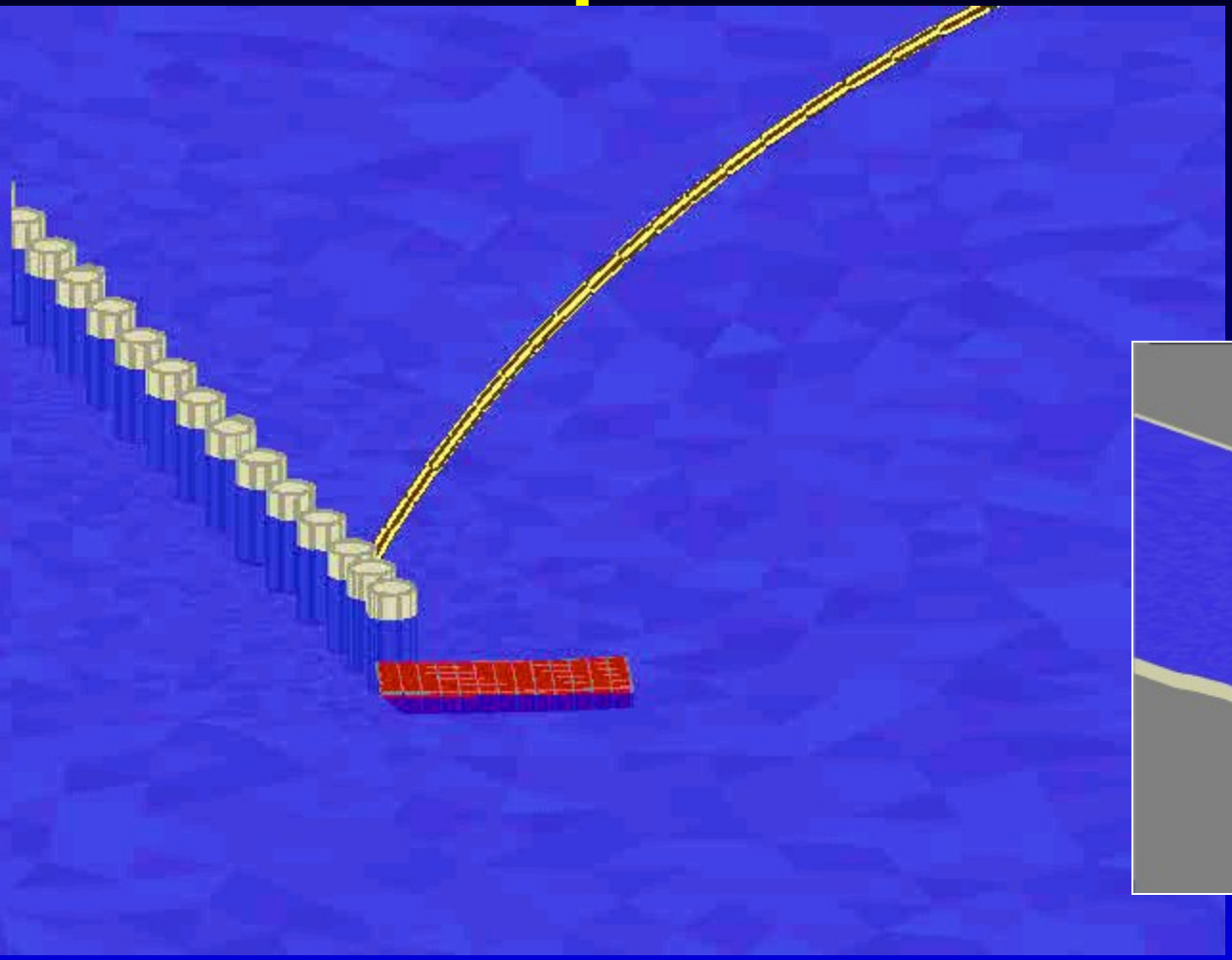
- **PI: Berger/Stockstill**
- **Problem:**
  - **Need improved models to assess environmental effects from project operations and vessels**
- **Products:**
  - **CHL CFD model (ADH) modified for vessel effects and sediment transport**

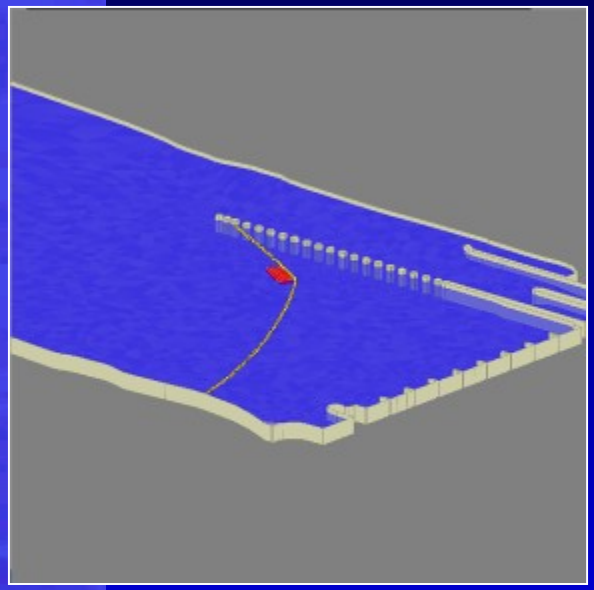
- **Benefits:**
  - **Improved Channel/Structure Design**
  - **Improved environmental quality**
  - **Better knowledge of vessel effects**

Hydrodynamic Design for Inland Structures: Hydraulic Design and Performance

- **Problems**
  - Design of New Structures and Rehab of existing structures, require improved hydrodynamic design tools
  - **Specifics**
    - **Emergency Closure Structures**
    - **Float-in Construction**
    - **Innovative Lock Approach Structures**
    - **Fish Passage Structures**
    - **Ice/Debris**
- **Benefits**
  - **Increased project reliability**
  - **Increased safety**
  - **Improved design tools**

Concept Design for Vessel Barrier from Coupled ADH and DEM Models

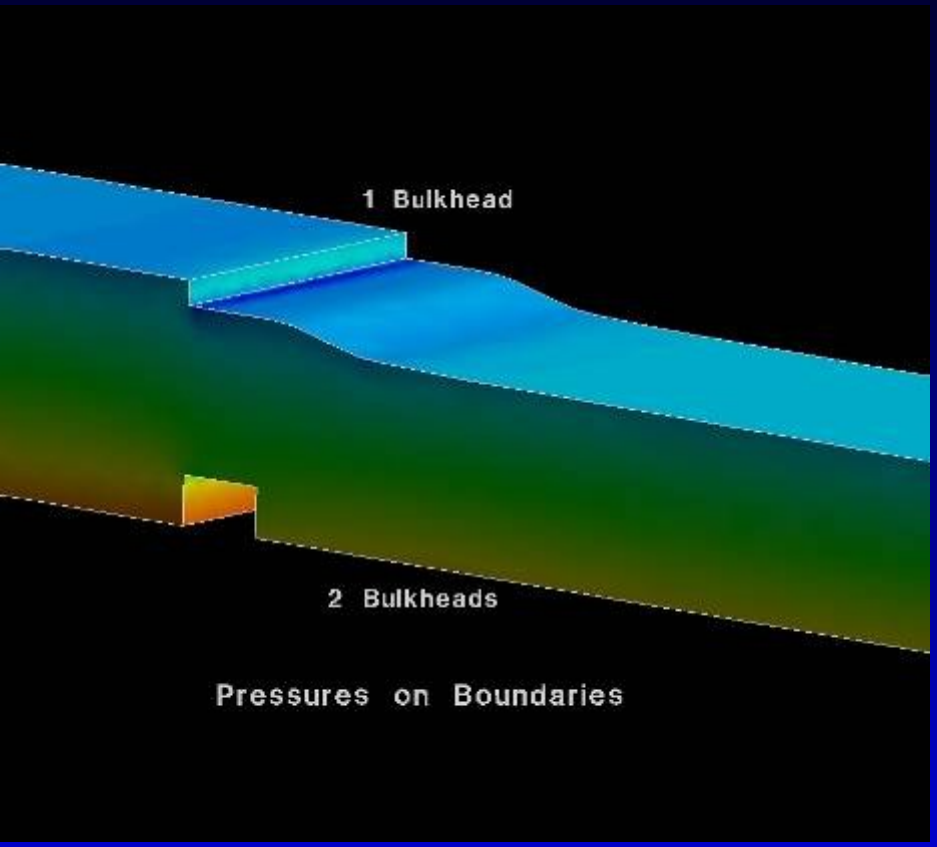


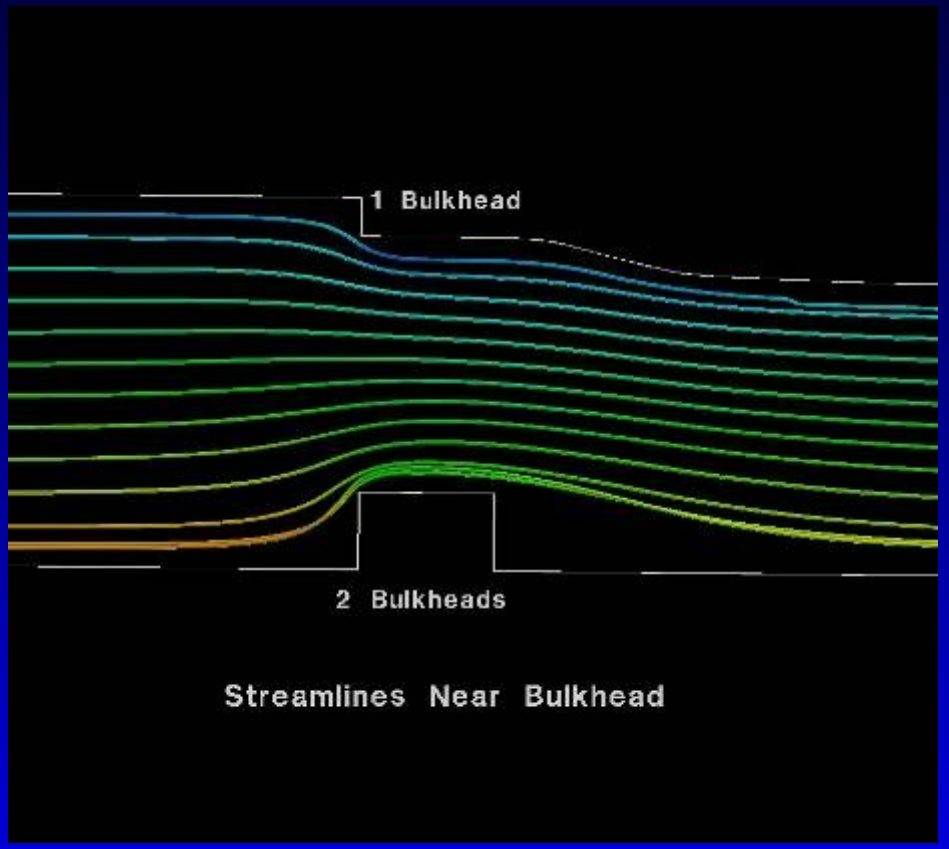


Hydraulic Design of Emergency Closure Structures

- Need to couple the DEM with the 3D Navier-Stokes module of ADH
  - Provide the CoE with a unique modeling ability to address fluid/structure interactions
  - Include forces on valves, gates, and emergency bulkheads deployed in flowing water
  - Applicable to computing hydraulic forces on float-In components

ADH Simulation of Bulkhead Installation

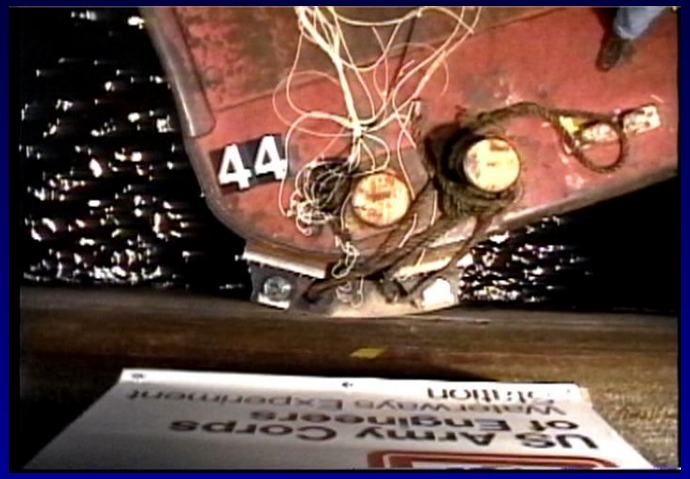




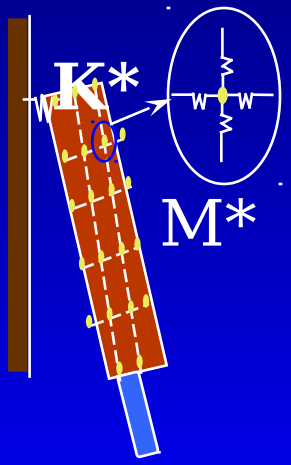
Inland Hydrodynamics and Infrastructure WA

Lock Walls for Barge/Vessel Impact Loads

- **PI: Bob Ebeling**
  - Incomplete Corps Lock wall impact design guidance



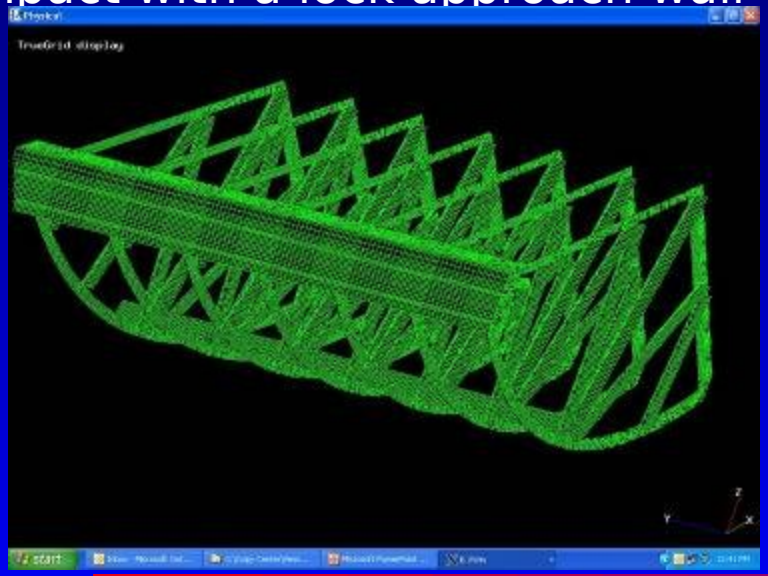
- **Purpose**
  - Complete Corps Lock wall impact design guidance for Barge Impact
  - Develop Corps Lock wall impact design guidance for Vessel Impact



- **Products:**
  - Analytical models of barge impact forces on rigid and flexible (lock) walls
  - Engineering Methodology used in new ETL on Barge Train Impact Forces with rigid walls
  - Guidelines to determine values for vessel impact forces with lock approach walls

Lock Walls for Barge/Vessel Impact Loads

- **Products (concluded):**
  - Guidelines to determine values of the limiting impact force due to lashing failures within barge trains
  - Guidelines to determine values of the limiting impact force due to plate buckling of the impact corner of a barge during a barge train impact with a lock approach wall



- **Benefits**
  - Optimized Lock Wall Designs, lower costs

Detection and Evaluation of Scour Protection

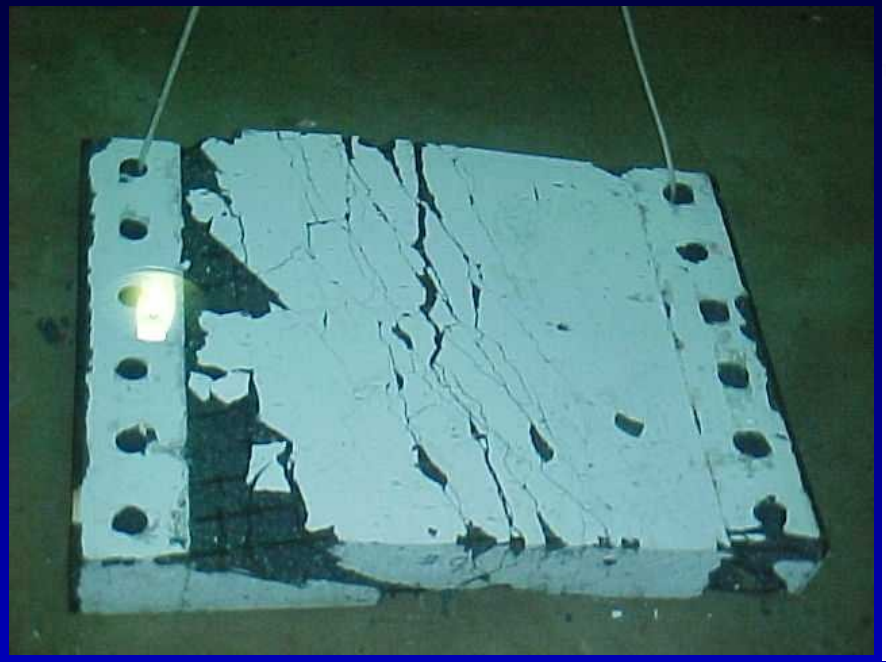
- **PI: John Hite**
- **Problem:**
  - **Scour at dams reduces project reliability; need better tools and guidance to measuring and predicting scour**
- **Products:**
  - Demo project (Emsworth)
  - Recommendations for tools/techniques for scour detection
  - Risk based program for scour protection needs
- **Benefits:**
  - Process to assess repair needs
  - Better prediction of maintenance/rehab costs
  - Reduced chance of failure

Emsworth Scour Protection Study

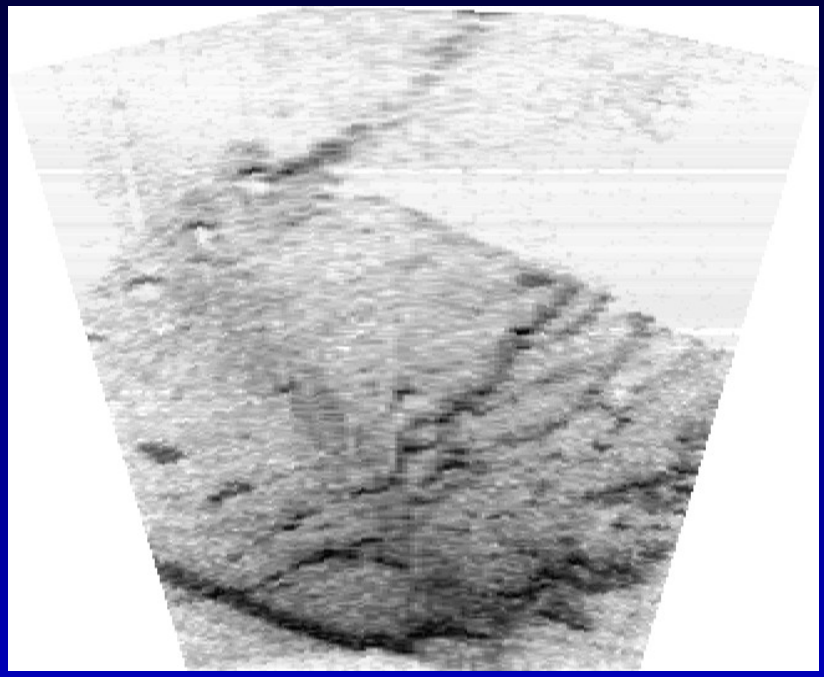
Flow over scour protection

Failure of scour protection

High Resolution Acoustic Imaging System



Concrete Reinforced Block



Sonar Image in Turbid Water

Developing Operating Standards for ADCP

- **Problem**
  - ADCPs widely used
  - Lack operating standards
- **Products**
  - Guidance for discharge
  - Guidance for point measurements
  - Working with USGS
- **Benefits**
  - Improved data quality
  - More appropriate application of technology

Focus Area - Inland Work Area - Infrastructure

- **Problem**
  - ⇒ Our nation's water highway systems may not be able to meet 21st century demands
    - Most key facilities are approaching or have exceeded their 50-year design life
  - ⇒ Improved understanding of existing condition, relation to strength capacity and remaining service life

- **Products**
  - ⇒ Innovative rehabilitation technologies to extend their life
    - Minimum service disruption and economically viable
  - ⇒ Condition assessment techniques and performance prediction models
    - Manage repair and scheduling tradeoffs

- **Benefits**
  - ⇒ Reduce unscheduled downtime
  - ⇒ Reduce repair costs due to damage and deterioration
  - ⇒ Provide key modules for development of asset management models
  - ⇒ Increase effectiveness in periodic inspections to assess actual structural conditions

Work Units

Soil-Structure Interaction for Seismic Evaluation of Earth Retaining Lock & Cantilever Walls

Inspection and Condition Assessment of Steel Structures

- Steel cracks and welding
- Nondestructive condition monitoring for tensioned steel members
- Acoustic camera for inspection

Monitoring and Rehabilitation of Concrete Structures

- Innovative lock rehabilitation techniques
- Monitoring of concrete navigation structures

Steel Cracks and Welding

- **PI: Guillermo Riveros**

- **Problem**
  - Lack of criteria and analytical methodologies for analysis of steel behavior from cracks and welding

- **Purpose**
  - Improve assessment of fatigue and weld cracked gates
  - Study numerical techniques (J-integral) for fracture analysis
  - Assess the connection of miter gate diagonals

- **Products**
  - **Criteria for performing fitness for service assessments**
  - **Analytical techniques for numerical fracture mechanics analysis**
  - **Analytical models to assess the pre-stress requirements of miter gate diagonals**

- **Benefits**
  - **Consistent and systematic guidance for performing a fitness for service assessment**
  - **Detailed fracture analysis**
  - **Reassessment of miter gate diagonal design criteria**

Nondestructive Condition Monitoring for Tensioned Steel Members

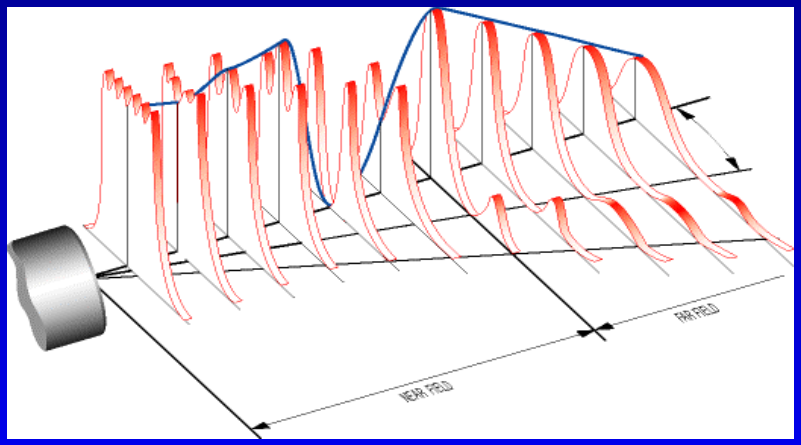
- **PI: Vincent Hock**

- **Problem**
  - **Inability to determine deterioration and loss of strength in critical components**

- **Purpose**
  - **Develop ability to determine condition of embedded structures**

- **Products:**
  - Technology to conduct quantitative measurements of tension and corrosion of embedded steel anchors and steel bracing

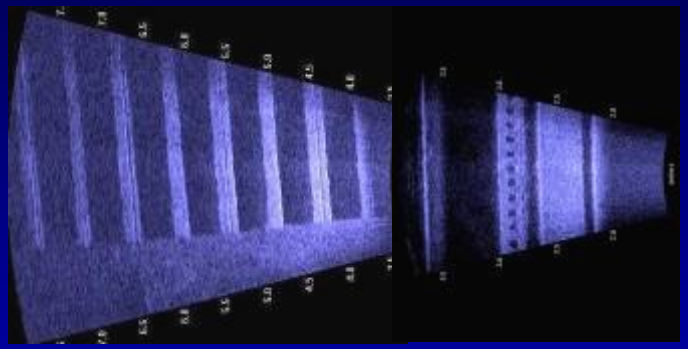
- **Benefits**
  - **Rapid, inexpensive, minimally intrusive condition assessment tool**
  - **High-quality data for effective management and prioritization of limited maintenance resources**



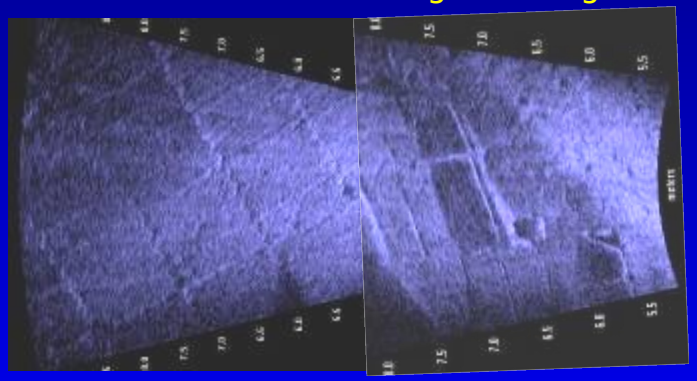
Acoustic Camera Inspection

- **PI: Jim Evans**
- **Problem**
  - Inspection of underwater structures
- **Purpose**
  - To improve inspections through innovative applications, i.e. high resolution acoustical imaging
- **Products:**
  - This will be summarized for FY06 in the form of a technical note and the enhancement of the prototype system
- **Benefits**
  - Improving the quality of inspections, reducing the cost and risk of inspections, and establishing a real time permanent record

Surface ridged casing



Underwater ridged casing



Inspection of Under water matting on MS River

Innovative Lock Rehabilitation Techniques

- **PI: Toy Poole**
- **Problem**
  - Poor performance of constructed and repair material
- **Purpose**
  - Develop technologies to extend concrete service life in navigation structures
  - Freezing & thawing, AAR, surface damage
  - Emphasis on expediency and cost
- **Products:**
  - EM 1110-2-2002 (Evaluation & Repair of Concrete Structures)
  - USACE GS 0391 (Concrete Rehabilitation for Civil Works)
- **Benefits**
  - Improve durability of repairs
  - Extend time until major rehabilitation or replacement

Damage from freezing and thawing

AAR damaged concrete

Monitoring of Concrete Navigation Structures

- **PI: Stan Woodson**

- **Purpose**
  - Develop engineering procedures for monitoring the condition of concrete navigation structures
  - Enhance ability to detect deterioration, identify causes, assess serviceability, predict future performance, and effectively schedule maintenance

- **Products**
  - Training on monitoring techniques and data interpretation
  - Guidance on design parameters to reduce long-term deterioration, assessment techniques, long-term monitoring procedures

- **Benefits**
  - Ability to develop long-term plans for maintenance and repair to facilitate the effective use of available resources and help insure continued operation of the system

FY06 Opportunities for Industry Input

- Dec 05, Navigation Area Review
- March 7-8, Currents at Locks Workshop
- April 18-20, 2006 Lock Inspection and Emergency Repair Workshop, Vicksburg, MS
- Fall 06, Navigation Area Review (DC)

Asset Management Work Area

- Improved Reliability Models for USACE Navigation Structures
- Condition Monitoring & Predictive Maintenance for Infrastructure

Asset Management

Improved Reliability Models for USACE Navigation Structures

PI: Yazmin Seda-Sanabria (GS

Problem: **Need for improved reliability models to predict actual field performance of Corps navigation infrastructure and assist in future investment planning of critical maintenance.**

- **Currently used mechanical and electrical equipment models are based on annual failure rates, not specific to navigation structures.**
- **Geotechnical models currently used yield inconsistent results on expected operational performance.**

Improved Reliability Models for USACE Navigation Structures

Products:

- **Time-dependent (capacity vs. demand) reliability models for electrical and mechanical operating components (FY06).**
- **Base geotechnical time-dependent reliability models (FY07).**

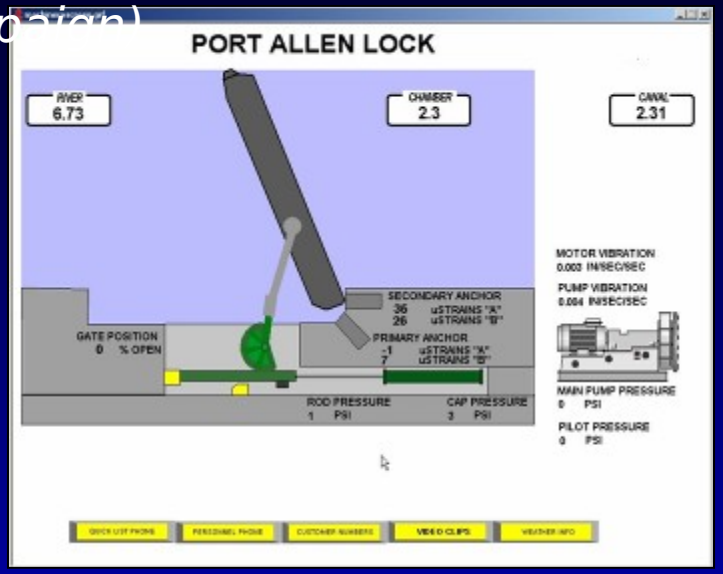
Benefits:

- **Significant cost savings on critical maintenance (including major rehabilitation) of Corps navigation infrastructure.**
  - **Improved engineering tools that can be integrated into economic models to make risk-based sound investment decisions.**

Asset Management
Condition Monitoring & Predictive Maintenance for Infrastructure

PI: Ashok Kumar (ERDC-Champaign)

- **Problem:**
  - Unscheduled maintenance can be disruptive and costly
  - Lock and dam gates are subject to failure due to excessive loads and wear of components
- **Products:**
  - Condition monitoring baseline data for:
    - ⇒ Structural components_
    - ⇒ Lock operating machinery
  - Guidelines for Predictive Maintenance
- **Benefits:**
  - Provides real-time indication of overall electrical, mechanical and structural condition
  - Reduces the likelihood of failure of fracture critical components
  - Reduces maintenance cost and personnel requirements
  - Improves safety and reliability of lock gate, dam gate and pumping station operations

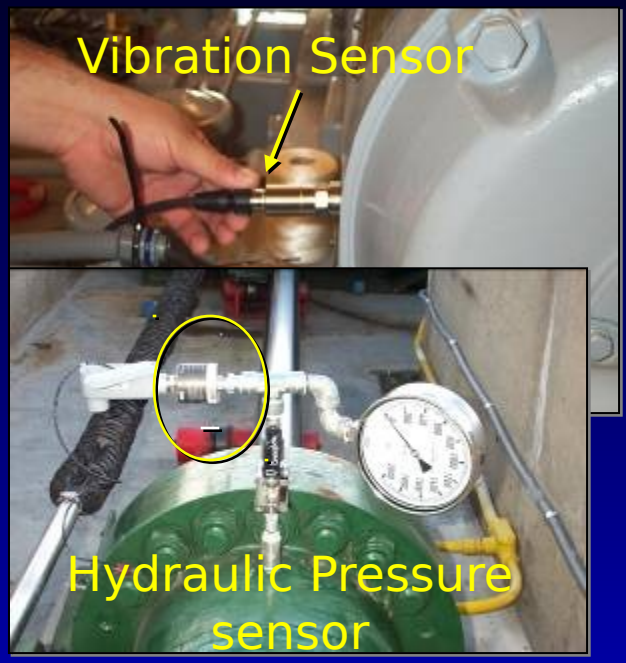


Asset Management
Condition Monitoring & Predictive Maintenance for Infrastructure

FY06 Activities- Port Allen Lock (New Orleans District)

- Establish Condition monitoring baseline data for
  - Lock operating machinery
    - pump motor current, Pump vibration, hydraulic oil pressure
  - Structural components
    - miter gate anchorage loading/strain

- Data acquired will be correlated with gate control machinery movement
  - interfaced to condition monitoring system

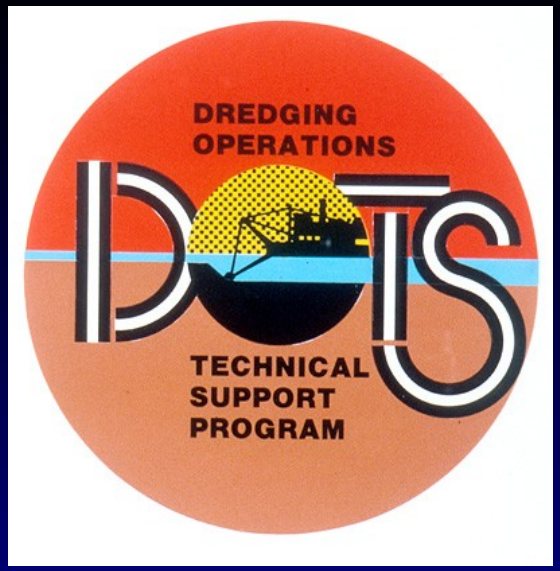


Dredging Operations Technical Support Program (DOTS)

Since 1978

DOTS MISSION AREA

NAVIGATION



DOTS
FUNCTIONS

- Technology Transfer
  - Direct Technical Support
  - Training & Outreach
  - Technology Application

DOTS Requests

- **District Navigation Related Need**
  - Review document
  - Site specific problem
  - Expert Testimony
- **Request Details**
  - Up to two man weeks of ERDC* expert
  - Site Visit
- **POC**
  - Dr. Douglas Clarke
  - 601 – 634 – 3770
  - Douglas.G.Clarke@erdc.usace.army.mil